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EVALUATION OF A FREE RADICAL PHOTOGRAPHIC MATERIAL DEVELOPED BY

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EVALUATION OF [redacted] PHOTOGRAPHIC MATERIAL STAT

SECTION I. INTRODUCTION

[redacted] based chemical research STAT operation which has been involved for a number of years in developing a non-silver photographic material. During the course of their research they have developed several hundred formulations differing in sensitivity, spectral response, color, etc. and have recently selected a duplicating material type E714 as being ready for pilot production. The product is currently available in a laboratory coated state on a polyester film base. A division of [redacted] has recently STAT been formed to manufacture on a production basis, non-silver photographic materials beginning with type E714. This report is a result of an evaluation of the type E714 material as a duplicating material for roll-to-roll duplication of aerial imagery.

SECTION II. MATERIAL DESCRIPTION

Film type E714 is a rapid dry processed photo-sensitive material which forms a near neutral dye image in exposed areas after optical development with red light. The spectral sensitivity lies in the violet (peak at 405nm) portion of the spectrum where exposures of a few millijoules per square centimeter form high density images. High resolution and negligible granularity are available as a consequence of the molecular nature of the image.

Development is accomplished by exposure to red light (wavelengths from 605 to 860 nanometers), and fixing by heating to 140°C in a moving air stream. During fixing, a solvent is removed from the coating in the form of a gas.

supplied equipment for exposure and processing STAT for the E714 material. This equipment consists of:

1. A special purpose contact printing fixture utilizing three small strobe lights.
2. A developing fixture consisting of a film holder capable of being driven beneath the developing light at varying speeds by a motor driven screw mechanism. The light consists of a 1 killowatt quartz iodine lamp and a Corning type 2408 red glass filter.
3. A deactivitation fixture consisting of a small oven equipped with heaters and an air blower to remove a solvent from the emulsion.

Optical development involves blanket radiation of the exposed material with red light. By varying the film temperature during optical development the resulting gamma may be varied.

The effects of temperature and red light illumination on development action could not be observed independently with the equipment since the radiant energy from the lamp was the only source of heat and therefore the two effects were not separable. It was therefore decided to construct a simple test chamber in which the film could be heated independent of the radiation effects of the red light, and therefore permit some measure of independent control. In addition, a low intensity cold cathode source was used in conjunction with the heated chamber to further isolate the effects of temperature and radiant energy.

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SECTION III. TEST RESULTS

Speed (Sensitivity) Measurements. In order to better understand the sensitivity aspects of the type E714 material an understanding of the basic exposure mechanism is necessary. The following is a simplified description of the exposure and development process.

In a conventional photographic emulsion the impact of a single photon on a silver halide crystal causes changes within that crystal resulting in its conversion to metallic silver upon chemical development. Only one photon is required regardless of the size of the crystal. Thus the impact of a single photon produces a sizeable (several microns typically) image spot. Typical molecular dye systems such as diazo require one photon for each dye molecule, thus in order to produce any density in a given area, the dye system requires significantly more photons (exposure) than the silver. The [redacted] material represents a compromise between the two systems in which one photon converts one molecule to visible dye, and the action of red light promotes a chain reaction converting adjacent dye molecules. Theoretically speaking this chain reaction could be continued until the speed and resolution were comparable to silver halide emulsions, however, the age old problem of background noise appears creating image fog and limiting the system. However, before this stage the material does exhibit a significant gain in speed over conventional molecular dye systems. Given sufficient exposure an image can be formed without development. Thus speed can be varied over a considerable range by changing the gain of the system (intensity or time of red light). The speeds reported herein represent the maximum sensitivity before noticeable fog.

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Speed measurements were made using a Macbeth sensitometer and verifying its calibration by using a film with a known speed when processed by a given technique. A typical D-$\log_E$ curve for the material is shown in figure 1, and figure 2 shows the position of the E714 curve in the exposure energy spectrum. Also shown for comparison purposes are Eastman Kodak Type 5427, an Aerographic Duplicating Film, 3M dry silver, Dupont Dylux, and a typical diazo material.

Density Range. As can be seen from figure 1 the material has an excellent density range, the base plus fog is 0.14 and the D max is approximately 3.2, giving a density range in excess of 3.0.

The gamma or slope of the D-Log$_E$ curve, can be varied by changing film temperature during optical development. Since higher temperatures tend to increase rate of development, time of exposure to optical development must be varied with temperature to maintain constant film sensitivity. By this means gammas ranging from 1.0 to 2.0 have been obtained with the rather elementary equipment on hand, and it is believed that a wider range would be possible with the right equipment. Exact temperature-gamma measurement was not possible because of the heating effect of the radiant (development) energy.

Although the exact mechanism of this variable development is not known, differential heating of differently exposed areas during development would seem to explain all of the observable facts. At low film ambient temperatures when the film is not well coupled to a heat sink, densities produced during initial stages of development absorb more radiation and thus become hotter than areas of low exposure. The increase in temperature in turn produces a more rapid development rate thus continually steepening the D-Log$_E$ curve. Heat sinking of the film during development either by contact with a surface or by high velocity incident air will reduce this avalanche effect and thus lower the gamma. Raising the ambient temperature of the film during development will further

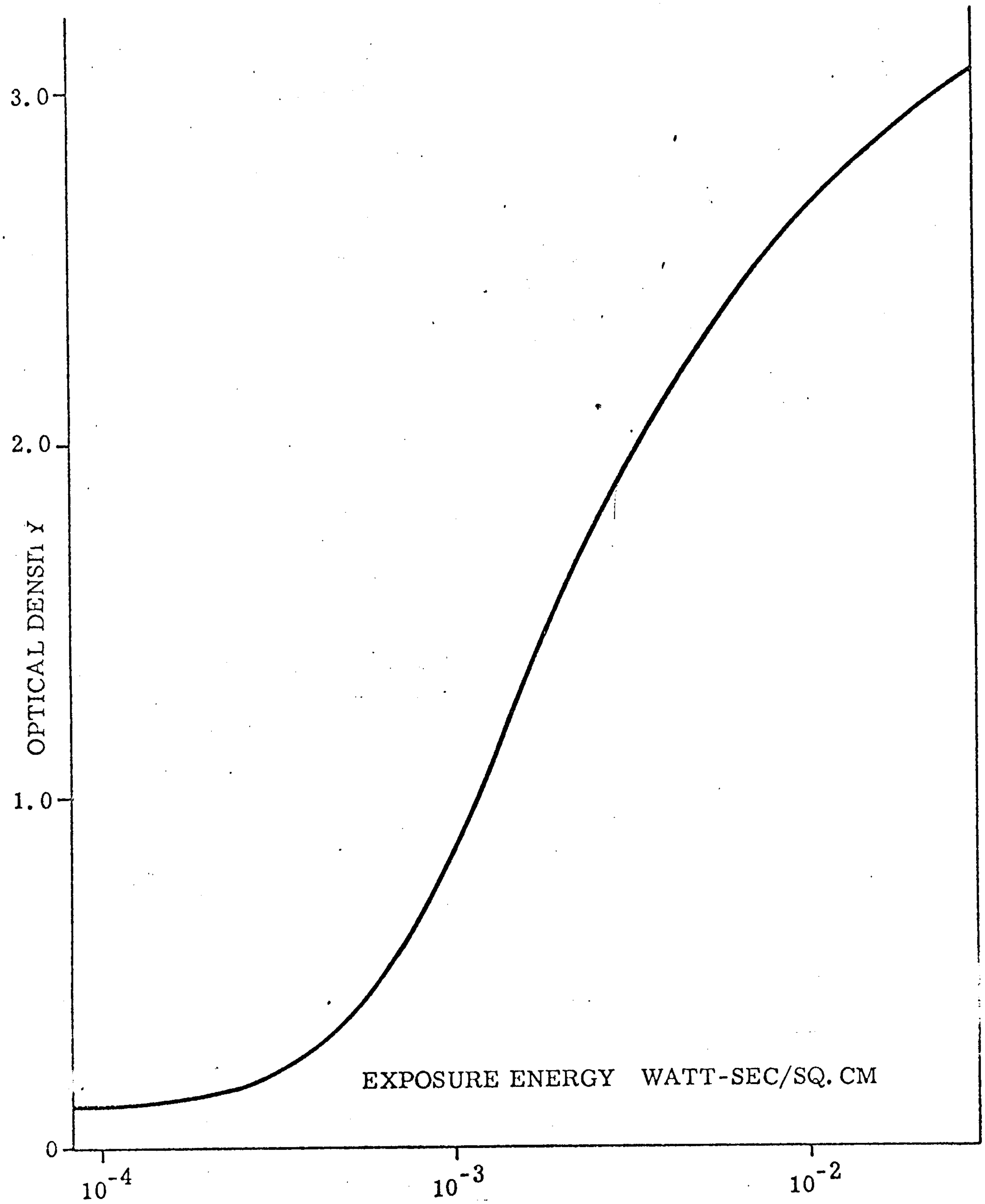

FIGURE 1. D-LOGE CURVE FOR E714

lessen the differences in temperature between highly exposed areas and those of low exposures thus reducing the gamma even more. An interesting aspect of this is the tendency for minute dust particles to absorb heat and re-radiate causing local high development rates producing black spots on film.

Resolution. The resolving power of the E714 material was measured using a 135X objective lens and a 10X eye piece to image a standard 1951 USAF resolution target. Under these conditions using tungsten illumination a resolution of 1200 line pairs per millimeter was achieved. This figure is probably not limited by the E714 material but by the optics used since the line width of the smallest detectable bar is approximately 1 wave length of the illuminating light. Resolution in the order of 2400 line pairs per millimeter have been reported for this material by Perkin-Elmer. This resolution figure was maintained over a wide variety of development conditions.

General Quality. The sensitive coating is about 0.4 mils thick on a 5 mil polyester base. Coating uniformity was poor, but typical of laboratory coating equipment. The variations in coating thickness should disappear when manufactured on production coating equipment. The adherence of the coating to the polyester base was excellent and the coating itself was quite durable.

SECTION IV. CONCLUSIONS

The material tested has all the necessary qualification for a duplicating media. It has the tonal range of a silver halide emulsion, excellent resolving power, approximately 100 times the speed of diazo type materials, and in addition is a dry working material. When in production its cost should be significantly lower than a silver halide product. Control and uniformity of developing temperature and intensity are important but are no more difficult to control than conventional

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processing parameters. An excellent initial application for this material would be roll-to-roll duplication of aerial imagery. Such a machine should be smaller and consume less power than other printer processing systems and be free from chemicals, water, drains etc. The gas given off during fixing is not toxic or corrosive, and can either be vented to atmosphere or absorbed in a low cost closed cycle filter system.